U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 567

SUGAR-BEET GROWING UNDER IRRIGATION

SUGAR BEETS are grown commercially in 18 States. In 11 of these States the growers depend upon irrigation for a part of their moisture in producing this crop. The successful production of sugar beets under irrigation depends not only upon an adequate supply of irrigating water, but upon a suitable system of crop rotation, a thorough preparation of the seed bed, careful blocking and thinning, timely and thorough cultivation, and a supply of livestock which will balance with the crop production of the farm and include the utilization of beet tops, pulp, and waste molasses. In addition to a suitable irrigating system the land should be provided with a satisfactory system of drainage, which may be either natural or artificial. Furthermore, the soil should be well supplied with humus, which may be furnished either in the form of stable manure or green crops plowed under.

Efforts are being made to relieve the labor situation by the construction and utilization of labor-saving devices, such as hill planters, beet toppers, beet-harvesting machines, and unloading devices, and by distributing the beet plantings and so adjusting the crop and livestock production on the farm that the labor is distributed over the season. This bulletin should be of interest to farmers in the Northern and Western States who depend in part upon irrigation for the water necessary for crop production.

Washington, D. C. Issued February, 1914; revised October, 1924

SUGAR-BEET GROWING UNDER IRRIGATION.

By C. O. Townsend, *formerly Pathologist in Charge of Sugar-Beet Investigations, Bureau of Plant Industry.*

CONTENTS.

THE SUGAR-BEET BELT of the United States, that is, the area within which the soil and climatic conditions admit of the successful production of beets for the manufacture of sugar, extends entirely across the northern portion of this country. The present southern boundary of this area is a somewhat indefinite and irregular line that may be said to extend from Virginia on the east to the southern part of California on the west. Efforts are being made to extend this area farther south, thereby increasing the productive sugar-beet belt. This can undoubtedly be accomplished with an increased knowledge of the requirements of the sugar-beet plant combined with its wide range of adaptability. As it is at present this belt is capable of maintaining hundreds of sugar-beet mills, the output of which would supply this country with the millions of pounds of sugar required for home consumption. A study of the great variety of soil and climatic conditions under which sugar beets thrive illustrates and emphasizes the wonderful adaptability of this remarkable plant to the wide range of conditions under which it may profitably be produced. (Fig. 1.)

This bulletin will be confined to a consideration of the conditions and cultural methods employed in those areas where, because of insufficient precipitation for the profitable production of sugar beets, water is artificially applied to the land. This area lies in the western and southwestern portions of the United States and is separated from the area of abundant rainfall not by a distinct line but by a zone varying in width, irregular in outline, and shifting now east, now west, with the seasonal changes in climatic conditions.

SELECTION OF SOIL.

In the irrigated portion of the sugar-beet belt there is a great variety of soils, varying from the distinctly sandy type through the sandy and clay loams, the silt, and volcanic ash to the heavy black adobe. In the selection of soil for sugar-beet culture it is safe to say that most of the soil types that are capable of producing good crops of other kinds will produce satisfactory beets.

The principal factors to be considered are the physical condition of the soil, the way in which it has been previously handled, and the climatic conditions. Much more depends upon these factors than upon the kind or type of soil. The physical condition of the soil depends to a considerable extent upon the previous crops and the

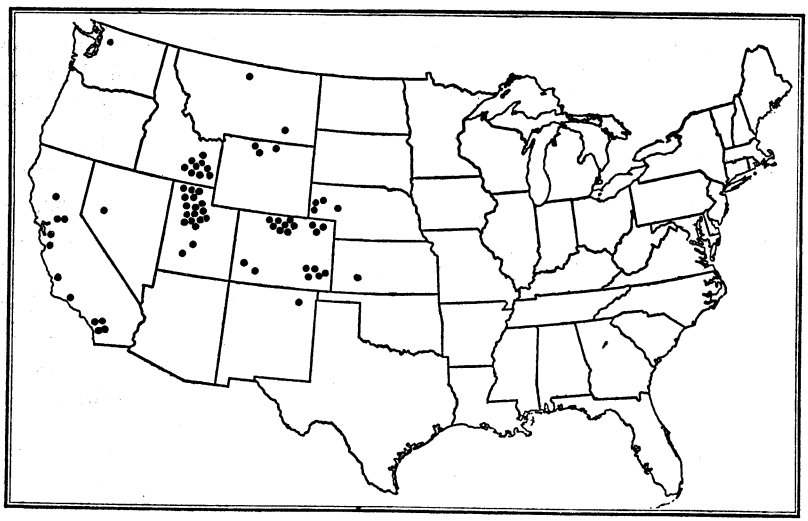

FIG. 1.—The dots indicate the location of the western beet-sugar mills. In the areas surrounding these mills more or less irrigation is necessary for the successful production of sugar beets.

way in which the soil has been treated. The soil should be well supplied with humus, not only to insure its fertility but to improve its moisture-holding capacity. The previous cropping should have been such that the ground is in good tilth and reasonably free from pests that are capable of injuring sugar beets. The soil should be well drained, either naturally or artificially, in order to prevent water-logging, and the ground should be kept sweet and at the same time free from an excess of alkali. Most of the western soils contain some lime, but an occasional application in many cases will be found beneficial.

Extremely sandy soils should not be selected for sugar-beet growing, especially in localities where high winds prevail in the spring. The shifting sands are liable to cut off the young plants or to cover

and smother them. The adobe and silty soils should be handled with considerable care to prevent baking and crusting, but this is entirely possible, and when properly handled they are excellent soils for beet production. It is generally assumed that new sod ground is not suitable for beets, but experience has shown that good results may be obtained from our western virgin soils. If such ground is to be planted to beets the sod should be broken in the summer, the ground fall plowed, worked down, and kept moist so that the sod will rot.

The kind and location of the subsoil are always important factors in selecting soil for sugar beets. In some cases the subsoil is very porous, so that the water passes rapidly through it with a tendency to leave the surface soil deficient in water and to leach out the plant foods. This condition can be relieved to some extent by increasing the humus supply in the soil and by giving special attention to firming the seed and root beds, in order that their water-holding capacity may be increased. If the subsoil is extremely porous and deep, so that sufficient water can be retained in the root bed only with difficulty, it would not be advisable to use the soil for beet culture.

The opposite condition, namely, a very hard subsoil, known as hardpan, prevails in certain localities. If the hardpan is close to the surface, so that there is not sufficient depth of soil to produce sugar beets, the field should not be used for this crop. If a good soil to the depth of 18 inches or more covers the hardpan, it will be safe to plant beets, provided the climatic conditions are favorable. Between these extremes of subsoil conditions are found all gradations of porosity and hardness, each of which should be carefully considered in selecting soil for beets.

Soil conditions favorable for sugar-beet culture in one locality might not be satisfactory in another locality on account of the climatic conditions. For example, in some localities a soil containing considerable sand might give excellent results with beets, while a similar soil in a locality where high winds prevail at planting time or shortly thereafter might make it very difficult to secure and to maintain a profitable stand. It is apparent, therefore, that in the selection of soil for sugar beets, and likewise for other crops, one should have a fair knowledge of the soil, the subsoil, and the climatic conditions. Any of the apparent difficulties in sugar-beet culture may be overcome in a large measure by the exercise of proper foresight and care in preparing the soil and in the subsequent care of the beets.

CLIMATIC CONDITIONS.

The principal climatic factors which have a direct bearing upon sugar-beet culture are temperature, precipitation, and winds. Both high and low temperatures have a direct bearing upon the growth

or quality of the beets. A study of the most successful sugar-beet localities of the world leads to the conclusion that beets of the best quality can not be grown where the average temperature for the growing season is much above 70° F. This does not mean that sugar beets can not be successfully grown in warm countries or in warm sections of a country, but it does mean that in such localities beets should be produced during the cooler portion of the year, which is now done successfully in certain portions of our own country. It is possible that beets adapted to higher temperatures may be produced by selection and breeding, and in this way the present large sugar-beet territory in the United States may be greatly increased.

Low temperatures are most likely to be injurious to sugar beets when the plantlets are just breaking through the ground. At this period the young plants are very tender and susceptible to injury by frost, but after the roots are established in the soil they rapidly become hardy and resistant to frost to a marked degree. Since the time of killing frosts varies from year to year in the same territory it is not always possible to avoid injury from this cause. A killing frost when the beets are coming up does not destroy the chance for a successful beet crop, but it often necessitates the expense and labor of replanting. It is therefore wise to delay the planting until the ground is warm and the growing conditions are otherwise favorable, since such conditions will rapidly push the beets beyond the period of frost injury. When the beets are mature they will stand a severe freeze without injury. The great danger from low temperatures at the end of the growing season is that the beets may be frozen in the ground, making the harvesting of the crop difficult or even impossible. To avoid this danger and the consequent loss that might result from such a condition it is advisable to get the beets out of the ground as soon as possible after they are ripe and to cover them to avoid freezing or drying. Beet roots are not injured for sugar-making purposes by freezing, provided they freeze and remain frozen until they are put through the mill, but alternate freezing and thawing causes them to decay and blacken, so that their value for sugar making is materially decreased.

The amount of precipitation, the time and manner in which the moisture falls, and the accompanying soil and weather conditions all have a direct bearing upon crop production. A given amount of rainfall in one locality may be ample for good crop production, while the same amount of rainfall in another locality may be entirely too small for satisfactory plant growth; and, indeed, in any locality a certain amount of rainfall may produce good crops in some fields and very poor crops in others.

Much depends upon the condition of the soil as to whether or not it is able to receive and retain the moisture. A large number of

showers may show several inches of rainfall in the aggregate, and yet they may have accomplished little good, if any, so far as crop production is concerned, because they failed to moisten the ground to a sufficient depth. On the other hand, one or more heavy, dashing rains may show a satisfactory total rainfall for the season and at the same time be entirely unsatisfactory from the standpoint of crop production. Indeed, such rains may be more injurious than beneficial, because of packing and crusting the ground. A record of the total rainfall for a season, or even month by month, is of little value unless we know the nature and amount of each precipitation. The point of most vital importance is to have the ground in condition to receive as much as possible of the moisture that falls upon it and then to make every effort to retain that moisture in the soil for the use of the crop.

The practice that prevails in some localities of letting the natural moisture escape from the soil, with the idea that more water can be applied when it is needed, is most pernicious and should be discouraged. If the moisture that gets into the ground in the form of precipitation or as irrigation water is retained by the soil it will enable the soil organisms to act upon the plant foods, rendering them available for plant growth. There is a feeling of safety in having an unlimited supply of water for irrigation purposes, but it should be remembered that irrigation costs money and labor; precipitation is nature's gift.

Winds have been briefly mentioned in connection with soil selection for sugar beets, but they have a still wider bearing upon crop conditions. Not only do high winds have a tendency to destroy young beets and other plants by cutting and burying them with shifting sands, but they have a marked influence upon the amount of evaporation from the soil. For this reason a given amount of moisture in a locality where hot, dry winds prevail during the spring is much less effective in crop production than is the same amount of moisture in a locality where such winds do not prevail, other conditions being the same. However, the injurious effects of winds may be overcome to a great extent by the use of proper cultural methods. For example, both the blowing of the soil and the excessive evaporation may often be reduced to the point of successful crop production by keeping the surface of the ground covered with a lump mulch. The mulch retards the evaporation, while its lumpy condition reduces the shifting of the soil. The cutting action of the shifting sand may be reduced by planting the beet rows at right angles to the direction of the prevailing winds when practicable and by attaching irrigating shovels to the drills, so that ridges capable of protecting the young plants will be thrown up between the rows at planting time. It is true that the slope of the land and the consequent direction of irrigation must also be considered in planting the

beets, but whenever practicable the rows should be at right angles to the direction of the prevailing winds.

PLOWING.

The time, the depth, and the kind of plowing done and the condition of the ground at the time of plowing are all important factors in preparing the soil for sugar beets. Aside from the fact that each crop grown should in a way be a preparation for the crops that are to follow, the actual preparation of the ground for the sugar-beet crop should begin immediately after the preceding crop is removed. At this time the ground should be disked or harrowed, depending upon the condition of the soil, in order that a mulch may be formed for

FIG. 2.—Breaking sod preparatory to deep plowing for sugar-beet growing. Deep fall plowing aids in storing the winter moisture, puts the plant food in usable form, and tends to destroy fungous spores and insect pests. A good crop of alfalfa plowed under in the fall is beneficial in adding humus to the soil.

the retention of the moisture and that the plowing may be better done. The time of plowing in actual practice varies from early fall to late spring. As a rule, the most satisfactory time to plow for beets is in the fall, for the reason that fall-plowed ground is in better condition to receive the winter moisture and consequently to respond to the freezing and thawing action which tends to put the soil in the best physical and chemical condition for plant production. Furthermore, deep plowing tends to destroy many of the fungous and insect pests injurious to beets and also promotes the early planting of sugar-beet seed. (Fig. 2.)

Some growers object to plowing in the fall because of the fear that the ground will blow during the winter. If, however, the ground is

left rough, the injury from blowing will be slight as compared with the advantages mentioned. If plowing in the fall is not practicable, the next best time is during the winter, if conditions will permit. In the irrigated sections, plowing should never be left until spring if it can possibly be done earlier. In the first place the rush of spring work is not favorable to the best kind of plowing, but more important is the fact that stirring the ground to such a depth so close to planting time promotes evaporation and often the entire seed and root beds are comparatively dry before the seed is planted.

If done in the fall, there is very little danger from deep plowing. Other things being equal, plowing to a depth of 10 to 14 inches or more will give the best results. Deep fall plowing not only furnishes a large storage space for winter moisture, but it enables the moisture to get well down below the surface in sufficient quantity so that the beet roots tend to grow to a good length, thereby increasing the tonnage. If for any reason the plowing is not done until spring it is not advisable to plow as deep as in the fall, since too much raw soil, not acted upon by the winter elements, would be thrown to the surface. Furthermore, it would be difficult to firm the root bed properly if plowed too deep, a condition which would be more injurious than the more shallow plowing. Subsoil plowing is not generally practiced, and in cases where deep plowing is done and the soil below the plowed area is not too hard for the beet roots to penetrate it readily subsoiling would not pay for the labor and money expended. Where for any reason the plowing can not be done to the desired depth and the underlying soil is hard, it will pay to run the subsoil plow.

In plowing, the furrows should be as uniform as possible in regard to both width and depth. This applies not only to each furrow throughout its length, but also to one furrow as compared with another. If the ground is disked or harrowed before plowing and the furrows uniformly turned, the foundation for good seed and root beds is well established, provided the ground was in proper condition from the standpoint of moisture when plowed. Ground is in proper condition for plowing when it is neither too wet nor too dry. Under no circumstances should ground be plowed when wet, since plowing under such circumstances injures the physical condition of the soil to an extent that often requires years to correct. Plowing should always be done when the ground is in what is called a friable condition; that is, when it is capable of falling apart as the furrow is turned so that there are no air spaces below, as is the case when the ground is too wet or when it is dry and cloddy. Good plowing when the soil is right physically is the only condition that will insure the making of good seed and root beds.

79615°—26—Bull. 567——2

THE SEED AND ROOT BEDS.

The preparation of the ground after plowing consists in those operations which put the soil in the best possible condition to germinate the seed and produce the crop. These operations will depend upon the time of plowing, the condition of the soil, and the climatic conditions. The seed requires a uniformly fine, firm, moist bed in order to produce a quick and uniform germination, which is especially desirable in beet culture. The more quickly the seeds germinate, the more certain is a good stand, which is the first requirement of a satisfactory crop. A uniform germination is desirable, because if the plants all start at once each plantlet helps others to get through to the light, and the plants will then be of nearly uniform size when ready to thin. The plants require a fine, firm, moist, well-aerated root bed in order to make a satisfactory growth. The root bed must be fine and firm because the plants must be held firmly in place during their entire period of growth, and the soil particles must be closely in contact with the feeding rootlets. The soil must be moist enough to supply the plants with mineral food in solution and with enough water to promote constant and rapid growth.

At the same time there must not be in the soil for any considerable period of time so much water that a free interchange of soil gases can not take place. If the gases produced in the soil can not escape and if an insufficient supply of air reaches the roots, the plant suffers and retarded growth results. The success with which the soil is put into the desired condition to meet these requirements controls in a large measure the resulting crop. If the ground is properly plowed in the fall when its physical condition is right, the root bed will be fine and free from air spaces. The winter moisture will usually pack the fall-plowed ground, so that the root bed will be firm. In the absence of natural winter rain or snow, winter irrigating should be done when practicable; otherwise, two of the most important objects of fall plowing will be lost, namely, the firming of the seed and root beds and the changes in the soil due to freezing and thawing.

If the ground is not plowed until spring, the seed and root beds must be artificially packed. This can best be done with a subsurface packer, which should follow immediately behind the plow. The subsurface packer consists of a series of wheels with knife-edges that can be pressed into the freshly plowed ground, exerting pressure downward and laterally at the same time. These wheels should be of sufficient diameter and enough weight should be applied so that they will go down into the root bed; otherwise, the desired results will not be accomplished. The packer should be followed immediately by the harrow, in order to form the mulch necessary to retain the moisture in the soil. This mulch should be maintained

until planting time, when, if the seed bed is not sufficiently firm, the roller and harrow should be used until the proper degree of firmness is produced. Due regard should be given to the condition of the soil when these implements are used, so that the flocculent condition of the soil is not destroyed. The ground should be so firm before the seed is put into it that even the hoofs of animals make but little impression upon it, as shown in figure 3. Too much emphasis can not be placed upon the importance of putting the ground in the right condition to receive the seed and to grow the crop, and every hour spent in properly preparing the seed and root beds will well repay the grower.

FIG. 3.—A properly firmed seed bed is one in which the animals' hoofs do not sink into the soil. This insures a uniform depth of planting and produces a more rapid and even germination of the seed.

Another important point in preparing the ground for beets is to see that it is properly leveled. The high points should be worked down and the depressions filled. In some fields this will require considerable labor, but it will pay to do this work thoroughly before planting to beets. A properly leveled field can be irrigated much more quickly, and, furthermore, if not properly leveled there will be high spots where the beets suffer from lack of sufficient moisture and low spots where the plants are injured by too heavy watering. The results in such fields are invariably disappointing from the standpoint of yields. It frequently happens that a field can not be perfectly leveled in one season, since the dirt that is pulled into the depression settles after moisture is applied and it still remains somewhat uneven. For this reason it is often wise to grow less expensive

crops than sugar beets, such as small grains, until the surface of the ground is sufficiently level to admit of uniform and easy irrigation before undertaking the production of sugar beets.

FERTILIZERS.

As a rule, the soils in the irrigated sections of the country are rich—that is, they contain in abundance the mineral elements necessary for plant growth; but in many cases these mineral elements are not soluble and therefore are not available for the use of the plant. Under such circumstances the soils, while rich, are not fertile. This distinction between a rich soil and a fertile soil should be kept constantly in mind in dealing with the subject of fertilizers. If one or more of the required elements is lacking or is not present in the soil in sufficient quantity to produce a normal plant growth, it is clear that such element or elements should be added in an available form. If, however, the necessary plant foods are all present in the soil but some of them are not soluble, the problem is entirely different and consists in so treating the soil that all the elements are reduced to soluble forms. Frequently the fertility of a soil may be increased by giving it proper tillage at the right time without the addition of any material. However, when we speak of a fertilizer we usually have in mind one or more substances which added to the soil tend to accelerate plant growth. These substances are classed either as vegetable or mineral fertilizers.

The vegetable fertilizers in common use are stable manure and green crops, while the mineral or so-called commercial fertilizers contain one or more of the elements known as nitrogen, phosphorus, and potash. Vegetable fertilizers contain small quantities of the mineral elements mentioned, but the principal function of the vegetable fertilizer is to so improve the physical condition of the soil that the elements already in the soil are rendered soluble and therefore available for the plant. Nearly all irrigated soils are deficient in decayed vegetable matter and humus, and for this reason the importance of making and properly utilizing the greatest possible amount of stable manure can not be too strongly emphasized. The quality of the manure will depend to some extent upon the kind of feed used, but even the poorest quality is too valuable to be wasted. It should be hauled out, spread evenly upon the field, and plowed under. (Fig. 4.) In case it can not be plowed under immediately after hauling, it should be disked into the soil to prevent it from drying up and blowing away. As already indicated, disking before plowing is good practice.

The amount of stable manure produced upon most farms is insufficient to supply the required quantity of humus to irrigated soils. For this reason the stable manure should be supplemented by plow-

ing under green crops. These are of two classes, those which do and those which do not store nitrogen from the air. If the supply of nitrogen in the soil as well as the supply of humus is deficient, nitrogen-storing plants, such as alfalfa, clover, peas, or beans, should be used as a green fertilizer. If the humus only is deficient, such crops as rape, rye, and sorghum may be used. It should be remembered that a good supply of humus in the soil not only improves its fertility but increases its water-holding capacity. A soil which is deficient in one or more of the mineral elements will not respond to the fullest extent to the addition of mineral fertilizer unless there is a sufficient amount of humus present to put the soil in good physical condition. Therefore, the physical condition as

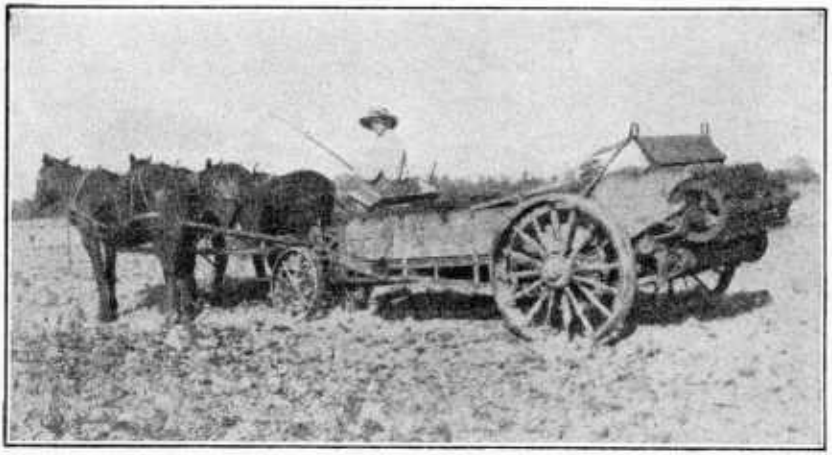

FIG. 4.—The manure spreader is one of the most important implements on the farm, However, if a spreader is not available the manure should be hauled out and spread by hand, and if it can not be plowed under immediately it should be disked into the soil so that it will not dry up and be blown away.

well as the chemical composition should be carefully considered in the efforts to increase the fertility of soils.

DRAINAGE.

At first thought, drainage in an irrigated section of the country might seem unnecessary, but experience has shown that under certain conditions the constant applications of water cause the soil to become water-logged. This is especially true where the surface soil is underlain with a soil stratum that is nearly level and impervious or nearly impervious to water. It is true that in many irrigated sections natural drainage is so nearly perfect that artificial drainage is not necessary. This may be due to the porosity or to the natural slope of the underlying stratum. However, in all cases where there is a tendency for the soil proper to become water-logged, artificial drainage should not be neglected. The water-logging of the soil

under irrigation is detrimental to crop production, not only because of the accumulation of so much water in the soil that the required amount of air is excluded from the plant roots but also because the alkali in the soil and water is carried to the surface of the soil and deposited when the water evaporates. Many of these alkalis when present in large quantities are injurious to plant growth to such an extent that fields formerly very productive have become nonproductive through the accumulation of these salts. On the other hand, areas that are nonproductive because of the presence of large quantities of alkali may be rendered very productive by properly draining the land and then washing out the excessive salts by means of irrigation. Figure 5 shows the effect upon beets of a lack of drainage.

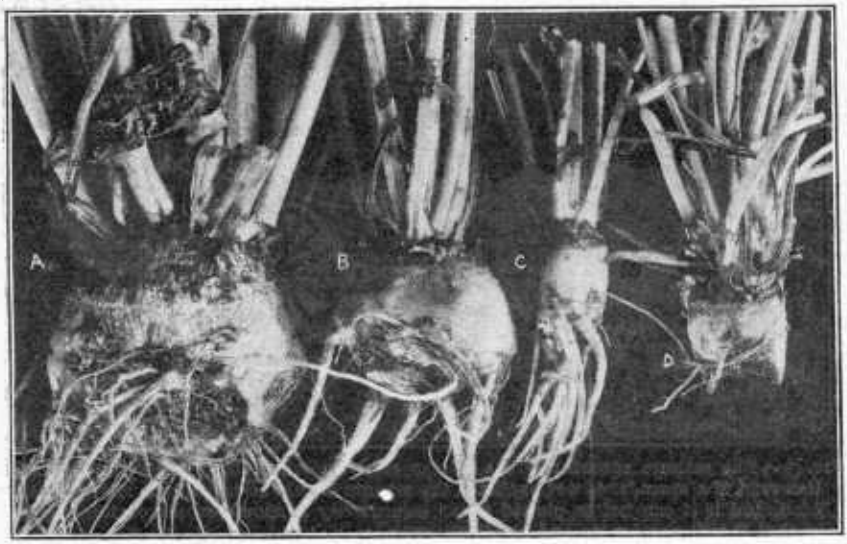

FIG. 5.—Sugar beets, showing the effect of a high water table, due to poor drainage.

There are two general systems of artificial drainage that may be used for carrying off the excess of water or for removing the excess of salts from the soil, namely, (1) the open ditch and (2) the blind ditch in which tile or a similar conducting channel is used to aid the flow of the water through the ground. The blind ditch is most often used, and while its initial cost is somewhat greater than that of the open ditch it is more economical in the end, as it still allows the use of the land and if properly constructed does not require the expenditure of time and labor necessitated by the open ditch, to keep it in working order. (Fig. 6.) The depth at which the tile should be laid and the distance between the lines of the tile will depend upon the soil conditions. The tiles should be so deep that they will not interfere with deep plowing and so that the water table will be several inches below the lower end of the beet roots; that is, 18 inches or

more below the soil surface. The lines of tile should be so close together that the whole of the desired area will be drained. There should be a gentle slope of each tile line toward its outlet, and the openings in the tiles should be large enough to dispose quickly of the excess water.

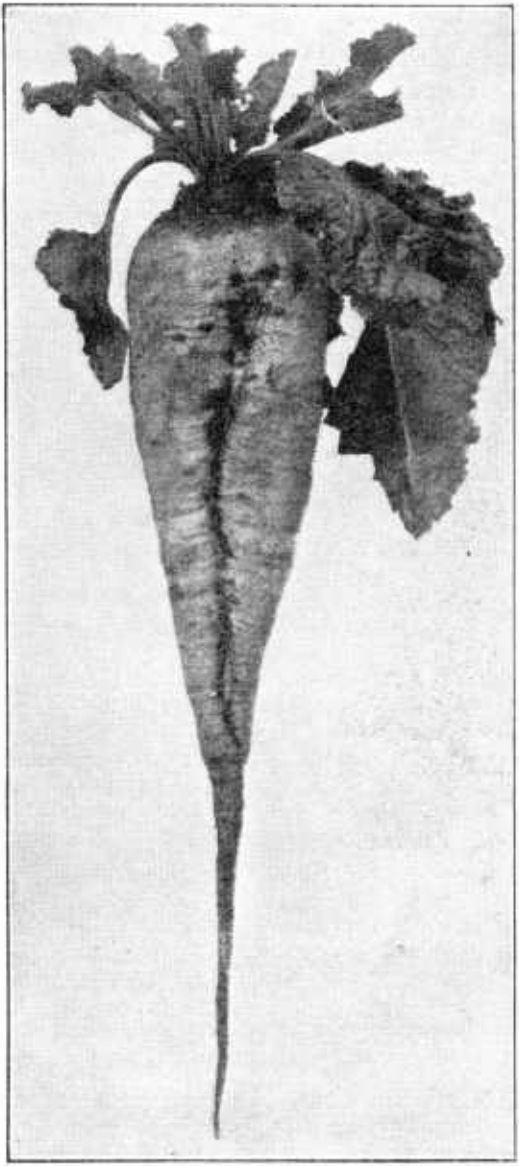

FIG. 6.—A good-shaped beet depends largely upon a firm, uniformly fine root bed with the water table 18 inches or more below the surface of the ground.

IRRIGATION.

The proper use of irrigating water is one of the most important factors in the growing of sugar beets under irrigation. The time and method of application and the quantity of water used are the essential considerations in the irrigation of sugar beets. In all irrigated sections there is some precipitation in the form of rain or snow, although this precipitation is uncertain both as to time and amount. However, it should always be conserved and utilized to the fullest extent and the irrigating water should be looked upon as insurance to carry the crop over periods of drought. In localities where winter precipitation is scarce, irrigation at that season is highly beneficial and should be practiced whenever possible, for reasons already indicated. It is usual in some localities to irrigate beets up; that is, the seed is planted in dry ground and the field is then irrigated in order to germinate the seed. The flooding method of irrigating beets up

is a poor practice and should be avoided (fig. 7), especially in fields in which the soil has a tendency to form a crust. (Fig. 8.) Irrigating beets up by the furrow method, if properly done, is generally successful, but it is much more satisfactory to irrigate before planting if enough natural moisture can not be retained in the soil to produce germination.

In irrigating before planting it is generally best to corrugate the land, making the corrugations 5 or 6 inches deep and about 20 inches apart. The water should then be run into the corrugations until the ground is thoroughly wet. As soon as the surface of the ground is sufficiently dry to work it should be harrowed down and planted. If properly done, a good stand of beets can be secured in this manner

FIG. 7.—A sugar-beet field, showing an improper method of irrigation by flooding the ground, which should be avoided.

without danger of crusting, and the ground should contain enough moisture to carry the plants beyond the thinning period. Whether the germination is produced by the moisture already in the soil or whether it is produced by irrigation, the plants should be carried just as long as possible after they are up before they are watered. In no case, however, should the beets be allowed to suffer severely for lack of moisture.

In watering beets after they are up they should never be flooded, but should be watered in furrows between the rows. This is especially important while the beets are small, since flooding at that time is likely to scald the beet stems and to produce a crust on the surface

of the ground around the beets, which cuts off the air supply in the soil and retards the growth of the plants. Usually suitable furrows between the beet rows can be made by means of the irrigating shovels, which may be attached to the cultivator. If the furrows made in this manner are not deep enough and smooth enough to carry the water readily, which will depend upon the slope of the land and the nature of the soil, they should be logged out. This can be done by running the corrugators behind the cultivator. If the corrugators are used for this purpose the runners should be 20 inches apart, more or less, to correspond with the distance between the rows of beets except when the soil is of such a nature that the water seeps out readily. In such cases irrigation in every other row is sufficient and the distance between the runners of the corrugators should be widened ac-

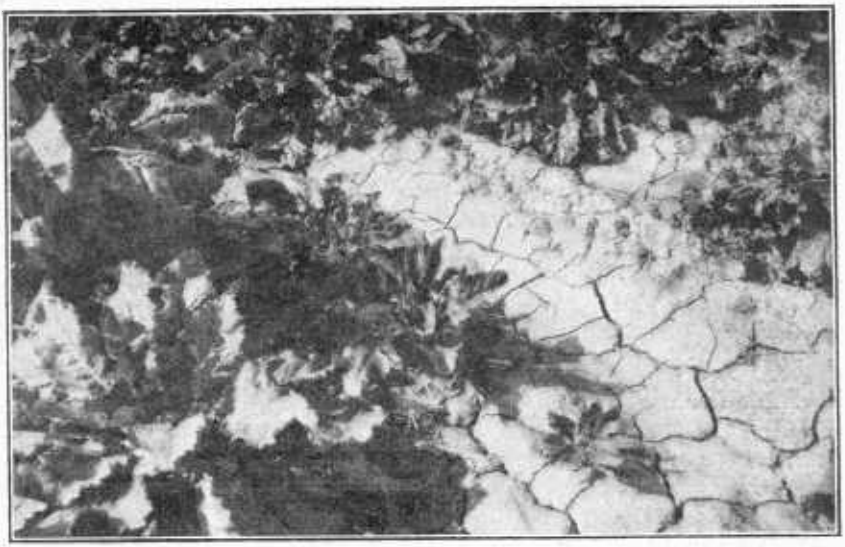

FIG. 8.—The surface of a sugar-beet field, showing its baked and cracked condition resulting from improper irrigation.

cordingly. The same implement can therefore be used to prepare the ground for watering before planting and after the beets are up. If it is desired to irrigate in every other row, it is necessary only to remove each alternate runner of the corrugator. (Fig. 9.)

After the furrows are properly prepared, the water should be allowed to run slowly through them, so that they will not overflow and so that the ground will be thoroughly wet down and the water seep out to the beets. Figure 7 shows the sort of flooding against which the above warning is directed and figure 8 the after results of such a method of irrigation. The soil bakes and cracks and the plants can not thrive under such conditions. After each watering the ground should be cultivated just as soon as the surface is dry enough to work. The mulch produced by the cultivator should be maintained by fre-

quent cultivation, in order to hold the water as long as possible. Cultivation should be made to take the place of irrigation to the fullest possible extent, and in no case should irrigation be expected to take the place of cultivation. In general, cultivation is less expensive than irrigation and it is much more satisfactory if done with care and with due regard for the requirements of the plants.

The quantity of water that should be applied in order to produce a crop of beets can not be stated in specific terms, since the water absorbing and retaining ability of different soils varies and the rate of evaporation varies in different localities and in the same locality under the constantly changing atmospheric conditions. It is seldom

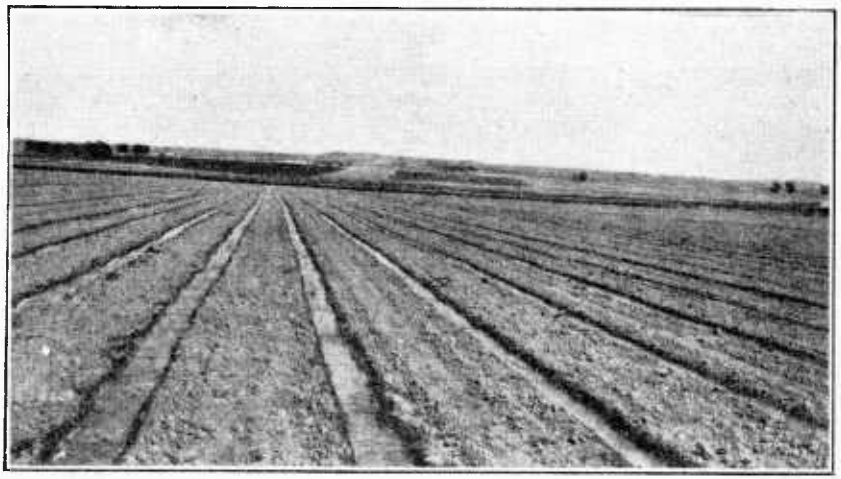

FIG. 9.—In irrigating the beets up, as well as in watering the beets after they are up, the furrow method is preferable to flooding, as it is less wasteful of water, less destructive to the crop, and leaves the soil in better condition for the future development of the plants.

that two fields will require the same amount of irrigating water to produce the best results. The plants themselves should be the index as to the quantity of water required. In no case should the beets be made to suffer to the extent of retarding growth. So long as the beets have a fresh appearance and a bright green color they are not suffering for lack of water, and if furrow irrigation is practiced there is little danger of giving them too much water. If the beets are flooded and the water is allowed to stand on the surface of the ground for several hours, the air is excluded from the beet roots and the plants suffer accordingly. A dark green color of the beet leaves usually indicates that the water supply in the soil is running low. This is often followed by a wilting of the beets and a consequent retardation in growth. If the wilted beets fail to revive during the night, practically no growth can take place, and water should be applied immediately.

HOLDING THE MOISTURE.

By nature soils vary within wide limits as to their water-holding capacity. For example, a fine, compact soil is capable of holding more moisture than a coarse or loose soil. One of the prime objects, therefore, in making fine, compact seed and root beds is that more moisture may thereby be retained in the soil for plant growth. Likewise, fall plowing not only affords an opportunity for the soil to absorb the winter rains and snows, but the ground becomes compact by the action of the elements and is for this reason capable of holding its moisture for a much longer time. It is almost impossible to pack the soil by artificial means as thoroughly and uniformly as it can be done by nature. For this reason spring-plowed land is much more liable to lose its moisture and therefore to require a greater amount of irrigation from the standpoint of compactness alone. In addition to these cultural methods as factors in retaining soil moisture, the importance of a good supply of humus in the soil should not be overlooked. Humus affords a good medium in which the soil organisms can live and thrive and liberate plant food, but they can perform their functions to a much higher degree because of the additional moisture which the soil is able to retain on account of the presence of the humus. If, then, the soil has been supplied with the requisite amount of humus and has been plowed uniformly deep at the right time, much has been done toward furnishing the plants with the moisture needed for plant growth. Special attention should then be paid to keeping the surface of the soil constantly in the form of a mulch. This mulch acts as a blanket in retarding evaporation from the soil below. Everyone is familiar with the moist appearance of the ground under a layer of straw, manure, or other loose covering as compared with the exposed surface of the adjacent ground. The dirt mulch over the field serves more or less perfectly the same purpose that is served by the straw or manure mulch.

PLANTING THE SEED.

If the seed bed has been thoroughly prepared, the principal factors to be considered in connection with planting the seed are the time and depth of planting, the quantity and quality of seed used, and the distance between rows. As already stated, the seed should not be put into the ground until the soil is warm enough to produce a quick germination and a rapid subsequent growth. Nothing is to be gained by putting the seed in the ground before the soil has reached the proper degree of warmth. Indeed, if the seed lies in the ground when the conditions are not right for germination it is liable to rot, and even if it does not rot, the resulting plants, when they do finally develop, will usually be weak and unsatisfactory.

The desire to give the plants every advantage of a long season often leads to the mistake of planting too early. Almost invariably

plantings that are made when the temperature conditions for germination and growth are right give the best results in tonnage and quality, and the beets sometimes mature in advance of the earlier plantings. On the other hand, the planting should not be delayed until the moisture has escaped from the seed bed. Therefore no date can be specified as the best time for planting, but the soil itself should be the guide in this operation. Usually there is a period of from four to six weeks, and in some localities a still longer time, when conditions are right for planting. This is a wise provision of nature and enables the farmer who desires to plant a large acreage and whose labor in caring for the beets is limited to make several plantings at intervals of a week or 10 days. By this means none of the beets need grow too large before they are thinned. This is a point that will be more fully considered under the subject of thinning the beets.

The seed should be planted just as shallow as is consistent with quick and uniform germination. The depth of planting will vary, therefore, with the nature of the soil and the condition of climate. The seed should always be put into moist soil and the soil should be capable of holding its moisture long enough to produce germination. In some cases these conditions will be met by planting the seed one-half inch deep, while in other cases it may be necessary to plant 1½ inches deep. It is questionable whether it is ever wise to plant more than 1½ inches deep, for the reason that the beet seed proper is comparatively small and the young plant must be able to get through to the light by using the reserve plant food in the seed. If the depth is too great, either the food supply will become exhausted before the plant breaks through the ground or it will become so nearly exhausted that the plant will be weak and spindling.

As an aid in holding the moisture in the soil, the drill should be provided with press wheels, which exert a firm, even pressure upon the soil directly over the drill row, as shown in figure 10. The principle in this connection is that a firm soil holds moisture better than a loose soil. Furthermore, a firm soil acts like a lamp wick and draws the moisture up from below. This emphasizes the importance of having a good supply of moisture in the soil below the seed bed as well as in the seed bed itself. If the pressure of the press wheels is not sufficient to bring the moisture up to the seed bed, the roller, preferably the corrugated roller, will be found useful. Care must be taken to have the ground in just the right condition when planted, so that the action of the drill shoes and press wheels will not destroy the flocculent and friable condition of the soil. If this condition is destroyed, the capillary movement of the soil moisture is impossible and it matters little whether the seed is planted deep or shallow, for the resulting stand will be a disappointment.

Having examined the soil and noted its flocculent condition and the distance to the moisture from the surface, the next point should

be to plant all the seed at a uniform depth. The importance of this will be apparent when one considers the operation of thinning the beets. Only two conditions are necessary in order to plant at a uniform depth. First, the surface of the ground must be smooth and firm, the importance of which has for several reasons been emphasized, and, second, the drill shoes must each stand on the same level. The drill can best be set in this respect by standing it on a smooth surface before it is taken to the field.

In order to get a good stand of beets, which is the first requisite of a satisfactory crop, plenty of seed must be used, so there will be no gaps or spaces of more than 10 or 12 inches in which there are no beets. Usually about 15 pounds of seed per acre will be sufficient

FIG. 10.—A sugar-beet drill, showing the four press wheels. The marks on the soil back of each press wheel indicate that uniform pressure is being exerted over each planted row.

if solid-row planting is practiced. As a means of conserving seed and avoiding the labor of blocking, hill planting is being tried with considerable success in several localities. A reasonable standard of germination and freedom from dirt is required of all beet seed before it is purchased; hence, the only remaining factor to be considered in determining how much seed to plant is that of the size of the seed balls. In general, the smaller the seed balls the greater the number of germs per pound and consequently the smaller the number of pounds required per acre. For solid-row planting about 15 pounds of seed should be sufficient for a good stand, assuming that the seed is up to the standard in germination and capable of producing strong plants. For hill planting not more than half as much seed will be required to produce a stand of beets. If a large

number of seeds germinate at the same time, each plantlet will help others to get through to the light; hence the importance of plenty of seed and a well-prepared seed bed.

In general, the most satisfactory distance between rows is from 18 to 22 inches. In many localities 20 inches has been adopted as the standard distance between rows, although in some cases rows as close as 16 inches will give the best results and in others it is better to have the rows as wide as 24 inches. It is evident that very fertile soil capable of holding an abundance of moisture will yield better results with narrow rows than will a less fertile soil with a lower water-holding capacity. In deciding upon the distance between rows it must be remembered that narrow rows are irrigated and cultivated with greater difficulty than are wider rows. Again, if the slope of the land or the nature of the soil is such that large furrows are required in irrigating the beets the rows should be farther apart in order to meet the requirement.

SPACING AND THINNING.

As already indicated, beet seed may be planted in solid rows or in hills. Having secured a good germination it next becomes important to thin the beets down to one in a place at suitable distances apart in the row to produce a good crop. The first step in reducing the beets to one in a place is that of spacing, which is usually done with a hand hoe used at right angles to the row or with a hill planter. By the first method a large number of the plants are cut out and the remaining beets are left in small tufts at intervals of 8 to 12 inches in the row. In performing this operation the hoe should be struck just deep enough so that the beets cut off will not grow again and so that all weeds that may have started in the row will be destroyed.

Several machines have been devised for spacing beets in a solid row, but they have not come into general use, mainly for the reason that in spite of all precautions the beets are not always uniform in size and stand, and judgment must be used in spacing; that is, the tufts that are left must sometimes be a little closer and sometimes a little farther apart in order to leave the strongest plants.

As soon as the beets have from four to six leaves the tufts or hills should be thinned to one in a place. This work must be done with the hands (fig. 11), since the beet plants stand so close together that no machine has been devised that is capable of doing the work satisfactorily. This is the most tedious and at the same time one of the most important operations in producing a crop of beets. It is seldom the case that two beets left in the same tuft will produce the same weight of beet root that would have been produced by either of the beets alone; hence the importance of thinning to a single beet can not be too strongly emphasized.

CULTIVATING.

There are three principal objects to be accomplished by the use of the cultivator, namely, the destruction of weeds, the retention of moisture, and the interchange of gases in the soil, all of which tend to supply the beet plant with food and to keep it in a healthy condition. The purpose for which the cultivator is operated should be kept in mind, and the cultivator should be fitted with attachments accordingly. In using the weeders care should be taken that they do not form a crust just below the mulch produced by the weeder blades. This may be avoided by attaching narrow shovel points just back of the weeder and so setting them that the points operate a little deeper than the weeder blades.

FIG. 11.—Thinning sugar beets. Owing to the closeness of the young plants this work must be done by hand.

Some growers are partial to the disks when the beets are small. These are useful if the main object is the formation of a mulch or if a light crust has formed which it is desired to break and at the same time to form a mulch. The disks, if properly set, prevent the dirt from being thrown over the young beets, which is a point that should be strongly emphasized at every cultivation, regardless of the kind of attachments used. The objection to the disk is that it leaves a furrow on either side of the beet row, and consequently the plants stand on a ridge, which is inclined to dry out. To avoid this condition a wide shovel point should be attached back of each of the disks and so adjusted that the furrows formed by the disks are filled in with loose dirt, leaving the surface of the ground level. (Fig. 12.)

While the beets are small it is safe to cultivate fairly deep and quite close to the plants. The depth to which the ground is stirred when

the beets are small should never be as great as the depth to which the roots have penetrated and never need exceed from 3 to 4 inches in order to accomplish the object of the cultivation. As the beets get older it is usually advisable to set the cultivator so that it does not work so deep or so close to the beets, for the reason that the feeding roots must not be disturbed. The manner in which the beets are handled while small, especially with reference to the soil moisture, will govern to a great extent the position of the feeding roots. If the ground is kept rather moist near the surface the feeding roots will develop near the surface and great injury may be done by the later cultivations. Withholding the water from the young beets as long as possible without letting the plants suffer will cause the feeding roots to form well down on the main root. If this is done

FIG. 12.—Proper cultivation aids in retaining the soil moisture, in promoting an exchange of gases between the soil and air, and in destroying weeds, thereby liberating and conserving plant food for the future growth and development of the beets.

a deeper mulch and one that extends closer to the beets can be maintained without injury to the plants. This will be helpful in retaining the moisture in the root bed and also in maintaining a free circulation of gases in the soil.

Before cultivating it is always advisable to examine the plants with reference to the length of the taproots and the location and length of the feeding roots. The cultivator should then be set accordingly. The time used in making this examination of the plants and in setting the cultivator, if done with care, is time well spent. A 4-row riding cultivator with foot guides is in more or less general use. The main advantage of the 4-row over the 2-row cultivator is the rapidity with which the beets can be cultivated. Many promising fields of beets are so injured by improperly adjusted and carelessly handled cultivators that they become sources of loss rather than of profit to the grower.

HOEING.

Beets receive their first and in many cases their only real hoeing at the time they are thinned. At this time the ground is or should be thoroughly stirred around each beet. The hoeing should be deep enough to destroy all weeds in the beet rows and to form a continuous mulch around and between the beets. The subsequent hoeing should be frequent enough to keep down all weeds and to maintain a continuous mulch in the beet row, so that the hoeing and cultivating maintain a continuous mulch over the entire surface of the field and keep it entirely free from weeds throughout the season. Unfortunately, in practically all sugar-beet localities all hoeing after the beets are thinned consists simply in cutting out the weeds in the beet rows. The consequence is that the ground in the beet rows is not stirred from the time the beets are thinned until they are harvested except at the points where weeds appear. This permits the formation of a crust, in many cases the entire length of the beet rows, through which an enormous amount of soil moisture escapes and is lost so far as its immediate effect upon the growth of the plants is concerned.

The destruction of weeds is of vital importance, since if allowed to grow they rob the soil of both moisture and plant food, but the stirring of the ground between the beets in the row should not be overlooked. The hoeings should be frequent enough to accomplish the destruction of all weeds as soon as possible after they begin to grow and to maintain a continuous mulch over the entire surface of the field until the beets are laid by.

HARVESTING.

The proper time for harvesting the beets is usually determined by certain tests which show the sugar condition and purity of the juice in the roots. Each sugar company has its standard for these factors of quality, and until the roots measure up to this standard they are not considered sufficiently mature to be harvested profitably. As soon as a sufficient number of fields show beets of proper quality for harvesting, orders are given and the roots are prepared and delivered to the sugar mill or loading stations. Beets are harvested by hand or by means of mechanical devices, of which there are several makes on the market. Harvesting beets by hand consists of several distinct operations, i. e., lifting, pulling, topping, piling, and hauling.

Lifting the beets consists in loosening them so that they can be easily pulled. Two forms of lifters are in general use. One is a double-pointed implement so constructed that one point passes along on either side of the beets and at a suitable distance from the surface so that the beets are slightly raised out of the ground. The other is a single-pointed implement somewhat resembling a subsoil plow. This passes along on one side of the beet row and loosens the dirt so that

the beets are easily pulled and is called a side lifter. The kind of lifter that will give the best results depends upon the condition of the soil. The side lifter usually has a lighter draft than the double-pointed implement. Aside from the draft, the important points are that all the beets be loosened and that as few roots as possible be broken. Both of these factors are often a matter of good driving. After the beets have been loosened they are pulled and thrown in piles or rows (fig. 13). The number of beet rows used in making one row of piles or one row of pulled beets is often a matter of convenience and usually consists of from 12 to 20 rows of beets. The principal point is that the greater the number of rows the larger the piles, which is of considerable importance in loading the beets.

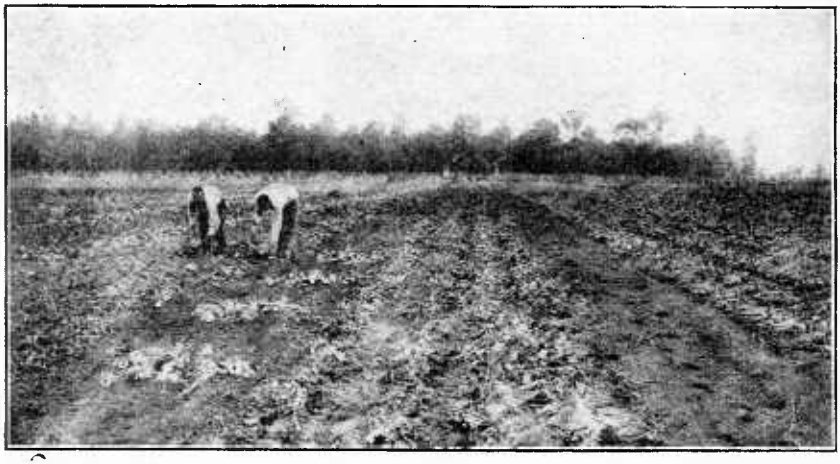

FIG. 13.—Topping and piling sugar beets.

After the beets have been pulled they are topped. This consists in cutting off each beet at the line of the lowest leaf scar, which is usually done by one stroke of a heavy knife. The object in topping the beets is to remove the leaves, which contain but a small amount of sugar, and to remove the crown or upper part of the beet, which contains a large percentage of the mineral matter taken up from the soil. The mineral matter prevents a certain amount of sugar from crystallizing, and for this reason should not be allowed to get into the juices in the mill. When the beets are topped the roots are thrown into piles (fig. 13), from which they are loaded on wagons by means of specially constructed forks; that is, the fork tines have knobs on the ends to prevent the tines from puncturing the roots. Before the beets are topped the ground where they are to be piled should be leveled and freed from clods and refuse material, so that nothing but clean beets will be forked on to the wagons.

Some of the beet-harvesting devices are designed simply to top the beets in the ground. These are followed by another implement which

lifts the roots, which are then gathered and thrown into piles. The complete mechanical harvesters, of which there are several on the market, lift, top, and in some instances pile the roots ready to be loaded on the wagon. Some of the harvesters are operated by horse-power, while others are driven by motors. (Fig. 14.) The mechanical harvester is both a labor-saving and a time-saving implement.

If the beets can not be hauled immediately after topping they should be covered to prevent evaporation or freezing. If the weather is not cold enough to freeze the beets, it is usually sufficient to cover the piles with the beet tops; but if there is danger of freezing, a sufficient quantity of earth should be thrown over the piles to prevent the roots from becoming frosted. When the beets are delivered to the sugar mill or loading station, they are tared. The tare consists

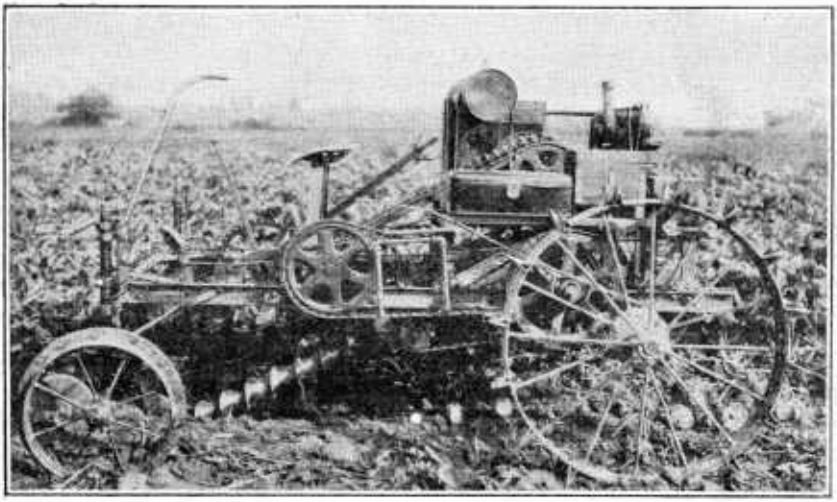

FIG. 14.—Several types of sugar-beet harvesting machines are in process of development. The successful harvester promises to be an important factor in reducing the labor and cutting the costs in sugar-beet production.

of two parts, the dirt tare and the crown tare. The dirt tare is the percentage of dirt that clings to the roots when loaded and the crown tare consists of the percentage of crown left on the roots, due to improper topping.

CROP ROTATION.

Every farm should have a well-defined system of crop rotation. The object of crop rotation, if properly arranged, is twofold. Each crop should leave the ground in better condition for the next crop than it was before, and each crop should prevent the propagation and development of plant pests. The fallacy that sugar beets injure the soil has not only been exploded but just the reverse has been found to be the fact. It is true that sugar beets take out of the soil the same elements that are removed by other crops, but in slightly different proportions. But, as has been stated, a large part of these

mineral elements is in the top, which, if kept on the farm and fed to live stock should be returned to the soil in the form of manure, so that in the end but little plant food is permanently removed from the soil by the beet crop. Furthermore, the beet crop leaves the soil in good tilth for the next crop. Experience in all sugar-beet countries has demonstrated the fact that larger crops of grain can be grown after beets than after any other crop so far as known. This seems to be due to the excellent condition in which the soil is left by the beet crop and to the depth of the root bed occupied by the beet roots. It is not apparent that sugar beets add to the soil any fertilizing material, but the fibrous roots that are left in the ground when the beets are harvested improve its physical condition.

No hard-and-fast system of crop rotation can be laid down for any community, but it must be carefully worked out for each farm. There are certain general principles that will apply to all crop-rotation systems. If sugar beets are to be one of the crops in the rotation system, the crop preceding the beets should be of such a nature that it can be harvested in time to plow the ground for beets in the fall. One of the crops in the system should be a legume, such as clover, alfalfa, peas, beans, or sweet clover. These are nitrogen-storing crops, and if the soil is deficient in humus, as is the case in most of the irrigated sections, a green crop should be plowed under. Not more than two sugar-beet crops should be grown in succession on the same field, chiefly for the reason that a continual cropping with sugar beets tends to promote the development of serious pests, such as leaf-spot, root-rot, and insects. It is true that more than two crops of beets may sometimes be grown in succession, but it is a dangerous practice and should be avoided.

LIVE STOCK.

One of the most important adjuncts of a farm on which sugar beets are grown is live stock, especially cattle and sheep. It is doubtful whether any sugar-beet territory can build up a permanent agriculture unless considerable attention is given to the production of live stock. At any rate, no agricultural country can attain its highest development without due regard to this particular line of agriculture. Not only will the live stock, if properly handled, produce an important part of the farm income, but they are very essential in the matter of soil improvement, which is brought about through the proper use of the barnyard manure. The keeping of live stock enables the beet grower to make the best possible use of the beet tops. This feed, in connection with roughage which is easily produced, keeps the live stock in good condition and enables the farmer to return the mineral elements in the tops to the soil and at the same time to increase the supply of humus, which is of special importance in irrigated sections because it increases to a marked degree the water-holding capacity of the soil.

Sheep as well as cattle thrive on beet tops, but it is wise to feed them sparingly at first and to increase the allowance as the stock become more accustomed to this feed. The practice in some localities of pasturing the tops after the beet roots have been hauled from the field has the advantage that it saves the time and labor of hauling them, but it is more or less wasteful. Furthermore, the ground is often injured by the trampling of the stock, so that altogether the most satisfactory plan is to gather and haul the tops to the feed yard, where they should be fed in properly constructed racks to avoid waste, or they should be used as ensilage.

If a regular silo is not available, a pit silo may be cheaply and easily constructed by making a trench 4 to 5 feet deep and long and wide enough to hold the beet tops and the roughage necessary to make the ensilage. (Fig. 15.) The trench can best be made with

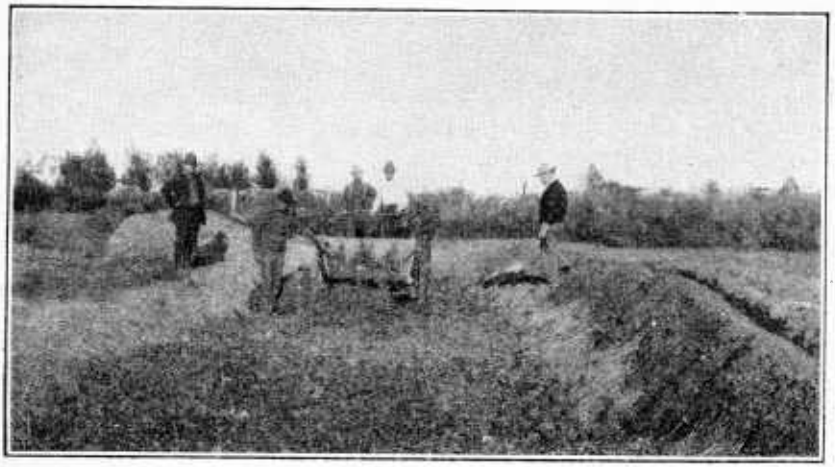

FIG. 15.—A pit silo in the process of being filled with sugar-beet tops. This is the most satisfactory method of preserving the beet tops for winter or summer feeding.

a plow and scraper. A layer of straw, about 6 inches deep, should be put in the bottom of the silo. Beet tops and straw or other roughage should then be added in alternate layers. The top layer should be straw, which should be covered with several inches of beet pulp or dirt to hold it in place and exclude the air. It is best to locate the silo convenient to the feed yard but where a wagon can be driven through it. By driving through the silo with each load of tops and roughage the lower layers will be packed. The material must be firmly packed when put into the silo, to prevent spoiling.

BY-PRODUCTS.

The by-products of the beet field and sugar mill that are of special importance to the farmer are the beet tops, pulp, molasses, and the waste lime. The value of beet tops as a stock feed has been briefly mentioned. If properly handled they form a valuable asset for the beet grower, and in considering the value of a beet crop they should

be reckoned at their real worth as a stock feed. (See fig. 16.) Many farmers sell the tops for a cash price ranging from $2.50 to $5 per acre. In this case the beet grower is the loser, for two reasons: In the first place, the tops are of greater value to him as stock feed; and, in the second place, if he allows the tops to leave his farm he loses their manurial value, consisting of a large part of the mineral plant food taken up by the beets in the process of growth, and also their humus value, which results from returning the tops to the soil in the form of stable or barnyard manure.

The most economical way to handle the tops is to gather them into piles soon after they wilt and before they become thoroughly dried. In this condition they can be gathered with much less loss than would be the case if they were left scattered over the ground until dried.

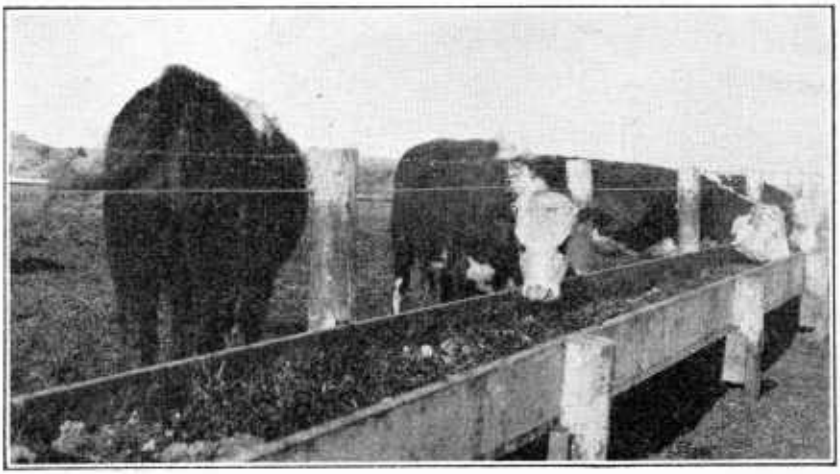

FIG. 16.—Beet-top silage with or without a small amount of sugar-beet molasses is an excellent feed for cattle or sheep. The trough method here shown is one of the best ways of feeding ensilage and similar feeds.

After they have cured in the piles they should be hauled to the feed yard or silo. Care should be taken to avoid and to eliminate dirt in the harvesting, siloing, and feeding of beet tops, as an excessive quantity of dirt may have a harmful effect upon animals to which it is fed. The manure resulting from the feeding of beet tops or beet-top ensilage should be hauled to the field and evenly spread, preferably with a manure spreader, and plowed under. If the tops are free from disease the manure can be profitably applied to the ground to be used for the next crop of beets. However, if any disease, especially leaf-spot or crown-rot, is noticeable on the beet leaves and crowns, the manure should be used only on ground that is not to be put into beets for two or more years; or, better, the freshly wilted beet tops should be put into the silo, preferably mixed with cut straw or corn stover. Leaf-spot spores are all killed in the silo.

Beet pulp is likewise an excellent stock feed. (Fig. 17.) This by-product is the refuse that remains after the beet roots have been sliced and the sugar extracted. As a stock feed it may be used either as

green pulp—that is, just as it comes from the mill—or it may be dried. The pulp is prepared for the drier by having the excess water pressed out, after which it is subjected either to direct heat or steam heat until it is approximately dry. It may be dried by itself or it may have molasses or other material mixed with it to improve its feeding value. The composition of ordinary dried pulp averages about 9 per cent protein, 0.5 per cent fat, 20 per cent crude fiber, 57 per cent nitrogen-free extract (carbohydrates), and 4 per cent ash (mineral matter). While the pulp, either green or dried, is an excellent stock feed, it is not a balanced ration and should, therefore, be fed with other protein material. The dried pulp is sacked and may be shipped long distances, while the wet pulp is usually fed near the mill, although it is sometimes transported a considerable

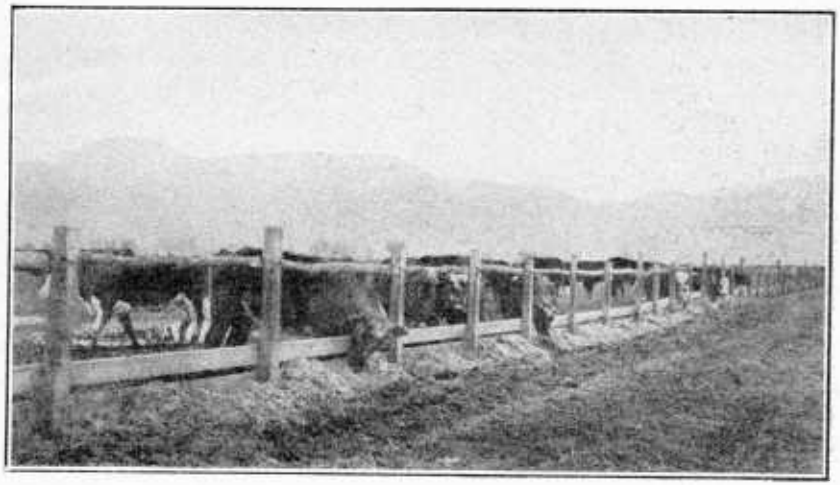

FIG. 17.—Cattle are very fond of sugar-beet pulp, and it makes an excellent feed when used with a moderate quantity of alfalfa hay. A better method of feeding beet pulp is shown in figure 16.

distance by rail. In any case farmers, and especially dairymen, will find this by-product an excellent addition to other stock feed. The dried pulp will keep almost indefinitely if stored in a dry place, and the wet pulp will keep for several months, even when piled on the ground in the open.

Beet molasses is the residue after the crystallizable sugar has been removed from the concentrated beet juice. In well-operated factories this amounts to 12 to 15 pounds for each 100 pounds of granulated sugar obtained. Beet molasses may be fed by itself or mixed with chopped roughage by spreading it over beet pulp, alfalfa, etc., or by drying it with beet pulp. Good results in feeding are obtained when 20 to 25 per cent of molasses is mixed with ground or chopped hay or straw. In addition to its actual feed value based upon heat units, it has a tonic effect, which greatly increases its value as a stock feed. From 3 to 5 pounds per 1,000 pounds of live weight may be fed daily. It is better to begin with the smaller amount and grad-

ually increase the ration from day to day. On an average about 50 per cent of the beet molasses is fed locally and the remainder is used by feed producers, who mix it with feeds high in protein in order to balance them and make them more palatable. The beet molasses should all be fed locally, if practicable, because of its high manurial value.

Waste lime is a by-product of the sugar mill which under certain conditions is of considerable value to the farmer in correcting the acid condition of the soil. It is well known that a soil should be neutral or slightly alkaline in order to procure the best results. Lime has the ability to combine with the injurious acids that develop in the soil and thereby render them neutral. If, therefore, a soil is inclined to be acid an application of lime will be beneficial. If just enough lime is added to combine with the acid in the soil, the result will be a neutral soil; that is, one which is neither acid nor alkaline. If an excess of lime is added, the soil will be rendered alkaline. Since a slightly alkaline soil is not injurious to sugar beets or other field crops, it is advisable in case a soil has become acid to give it a good application of lime. Ordinarily, an application of 500 to 2,000 pounds of waste lime per acre will correct the acidity and otherwise improve the soil. In this connection it should be stated that poorly drained soils are the ones most inclined to become sour, a fact which still further emphasizes the importance of good drainage. It is not necessary that waste lime from the sugar mill be used to correct soil acidity. Any finely divided or air-slaked lime will serve the purpose. However, waste lime may usually be had for the hauling and for that reason is an inexpensive remedy for sour soils.

The physical condition of certain soils may be improved by the use of lime. This is especially true of heavy soils which tend to become too compact. An application of lime to such soils will often render them porous, thereby enabling the farmer to prepare more satisfactory seed and root beds for his crops. Furthermore, such soils will more readily absorb and retain moisture and allow the air to circulate more freely through them.

Lime is in itself an important plant food, and soils deficient in lime may easily be corrected by an application of the waste lime from a sugar mill. This by-product, known as waste lime, lime cake, or sludge, contains, upon a water-free basis, about 80 per cent of lime as calcium carbonate. In addition, it contains from 0.1 to 0.4 per cent of nitrogen, 0.3 to 0.9 per cent of phosphoric acid, 0.1 to 0.4 per cent of potash, and 5 to 14 per cent of organic matter, all of which give it some value as a fertilizer. The value of this by-product as a soil improver has never been fully realized, and it should come into more general use, especially on heavy soils. Waste lime has an actual value that is recognized in Europe not only by the farmers, who use large quantities of it on the land, but also by the manufacturers of commercial fertilizer, who employ it to good advantage as a filler or makeweight in the manufacture of their goods.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1926